A reanalysis of UK wind speeds using the WRF mesoscale model

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A REANALYSIS OF UK WIND SPEEDS USING THE WRF MESOSCALE MODEL

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Abstract

Wind is the fastest growing source of renewable power in the UK and will contribute most to the targets for 2020 [1].

Integration of large amounts of wind generation into the grid presents serious challenges, since wind generation is variable in both time and space, and is not dispatchable in the way that thermal generation is.

Key to overcoming these challenges is a detailed understanding of the resource, as this will determine when and where power generation can be utilised, what networks are best suited to transport it.

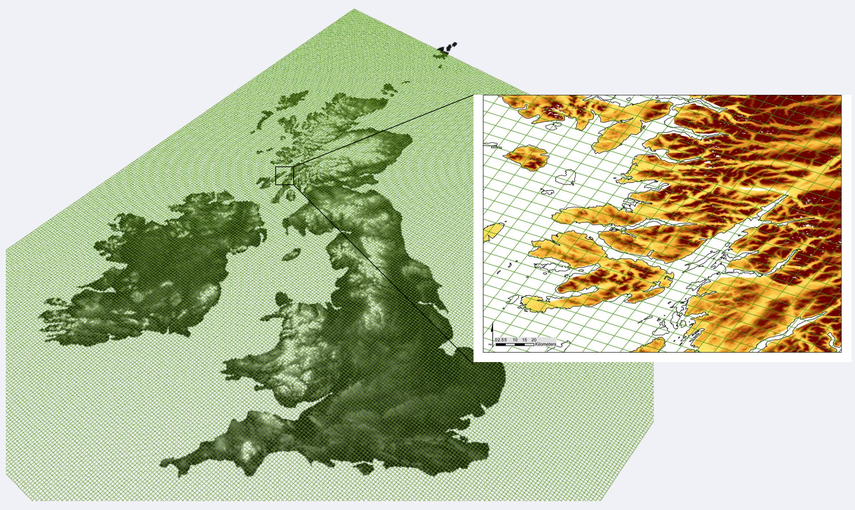
Wind speed measurements onshore lack spatial resolution, and are influenced by local terrain and surroundings. Offshore, measurements are difficult to obtain at sufficient temporal and spatial resolution.

Mesoscale modelling is fast becoming a key tool for both short-term forecasting and long-term resource analysis.

The work presented here is based on the results of a four-year reanalysis at 5km resolution over the UK and surrounding waters [2]. The final project will cover the UK at 3km resolution and cover a 10-year period.

Methodology

The Weather Research and Forecast (WRF) model [3] is used to simulate wind speeds over the UK. NCEP/NCAR final analysis data is used as boundary conditions every 6 hours, with analyses nudging used on the outer domains. Three nested domains down to 5km.



Model domain grid at 5km resolution

Above: the innermost domain over the UK at 5km resolution on a rotated polar stereographic projection

Top right: inset showing the 5km grid over the complex coastal terrain on the west coast of Scotland

Configuration

Current resolution Planned	50, 10, 5 km 27, 9, 3 km
Analysis length Planned	4 years 10 years
Vertical levels	27
Boundary conditions	NCEP/NCAR FNL
PBL scheme	MYJ
Land-use	MODIS

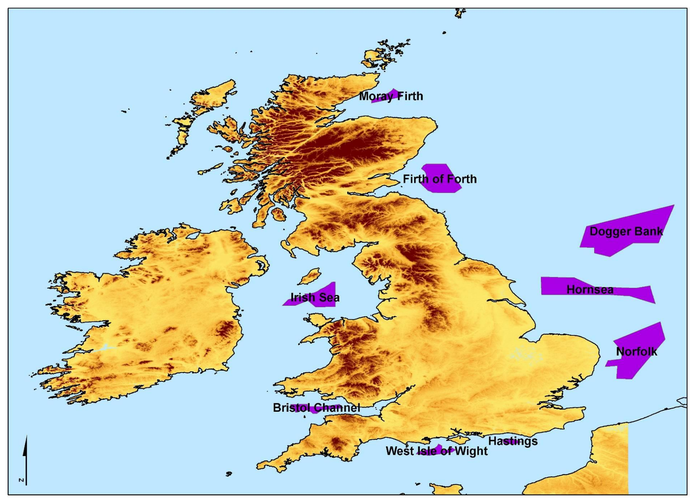
Summary of model configuration

Case Study

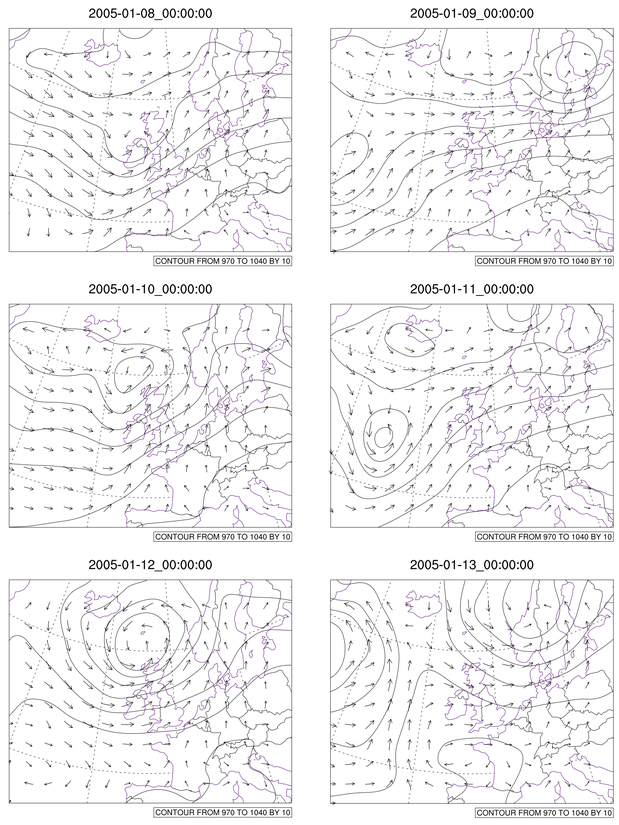
January is likely to be challenging month for future network operators. Intense storms are frequent, interspersed with periods of calm and cold weather.

Understanding how future offshore generation will behave these conditions is critical for ensuring a secure and stable network.

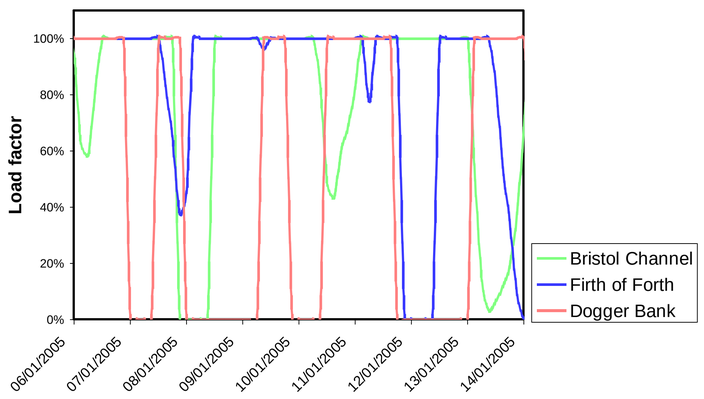
This case study uses the meteorological conditions for one meteorologically active week in January 2005 to predict the power outputs from future developments in the Round 3 areas.



Round 3 Windfarm zones: future developments were modelled by placing a number of generic 5MW turbines in each zone up to the maximum capacity and deriving power from hourly wind speed.



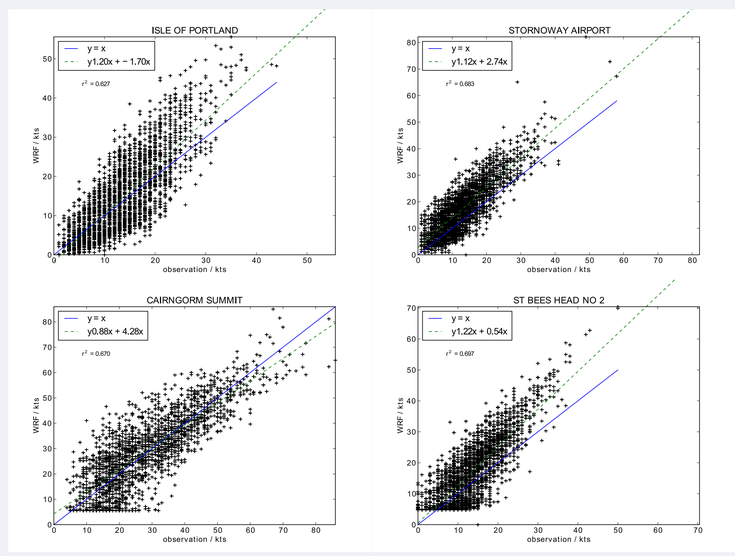
Synoptic conditions: a series of depressions cross to the north of Scotland, with wind speeds sometimes exceeding turbine cut-off speed, interspersed with calmer periods.



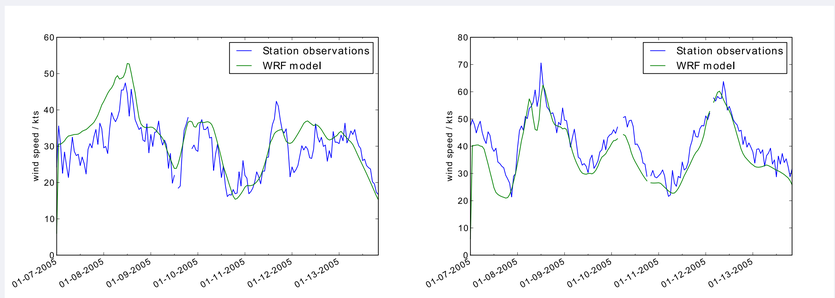
Power output as a percentage of total capacity: large power swings are seen over short periods. However, the timing is significantly different across sites. Only three sites are shown here for clarity.

Validation

Model outputs have been compared to 80 onshore met stations across the UK, selected by site exposure. Offshore speeds have been compared to data from buoys and offshore platforms in the North Sea.



Onshore validation: observations against predictions observations for one year at a selection of met sites around the UK. A total of 80 met stations have been chosen for validation



Offshore validation: model predictions compared to wind measurements from offshore platforms in the North Sea for the period 7th – 15th January 2005. Data courtesy of Shell UK.

Future Work

Simulations are ongoing on HECToR, the UK's high-end computing facility. Resolution has been increased to 3km in the inner domain and the model code has been modified to average wind speeds over time, and directly interpolate to hub heights. This model setup will now be used to:

Produce a 10 year reanalysis.

Validate power production figures against existing wind farms.

Produce detailed analysis of future power flows.

References

1. UK Renewable Energy Strategy, 2009. Department for Energy and Climate Change
2. Vieno, M., Dore, A. J., Wind, P., Di Marco, C., Nemitz, E., Phillips, G., Tarrason, L., and Sutton, M. A.: Application of the EMEP Unified Model to the UK with a Horizontal Resolution of 5 x 5 km², Atmospheric Ammonia - Detecting Emission Changes and Environmental Impacts, (eds. M.A, Sutton, S. Reid, and S.M.H Baker), Springer, 367-372, 2009.
3. Description of the Advanced WRF Model Version 3, 2008, William C. Skamarock Joseph B. Klemp Jimy Dudhia David O. Gill Dale M. Barker Michael G. Duda Xiang-Yu Huang Wei Wang Jordan G. Powers

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